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THE LORENZ FUNCTION OF LIQUID POTASSIUM

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We have separately measured the thermal conductivity ($\kappa$), electrical resistivity ($\rho$) and thermoelectric power ($S$) of K from just below the melting point, 335.5K, to 700K. Our main reason for doing so is that electron-electron (e-e) scattering has been observed in solid K through its effect on the thermal resistivity, and it would be of obvious interest to determine if such scattering occurs in a similar way in the liquid state. Furthermore, we wished to determine the transport properties of liquid K accurately, since it has been suggested as a reference material for measurements of $\kappa$ of liquid metals. The measurements were carried out with an absolute guarded longitudinal heat flow apparatus which permitted measurements of $\rho$ to 0.9%, $\kappa$ to 1.5%, and $L$ to 1.4%. The $\kappa$ data were found to be unaffected by convection. More details regarding the apparatus, the estimated errors, and the $\rho$ and $S$ data, will be given elsewhere; here, we shall concentrate on the data for the Lorenz function $L = \kappa\rho/T$, which do indeed indicate the presence of e-e scattering.

The $L$ data are shown in the figure, along with some of our previous results for solid K. Both for solid and liquid K $L$ clearly differs from the Sommerfeld value, $L_0$. To study the difference $L-L_0$, which well exceeds the probable error, we write the thermal resistivity as

$$W = W_{ee} + W_{ep}$$

where the meaning of $W_{ee}$ is obvious, and $W_{ep}$ gives the effect of scattering of electrons by phonons in the solid state, and ionic density fluctuations in the liquid state. $L = \rho/WT$ differs from $L_0$ since $W_{ee}$ has no appreciable counterpart in $\rho$ at these temperatures, and, in addition, since $e-p$ scattering is in part inelastic. For solid Na, K, Rb and Cs (cf. 1 and references) we have written $W_{ee} = BT$, and, correcting for the effect of inelastic $e-p$ scattering, have fitted the above equation to the measured $W$ data, to find $B$ values which are supported by detailed calculations of e-e scattering in these metals.

For liquid K it may be shown that inelastic $e-p$ scattering may be ignored; hence, $\rho_{ep} = L W_{ep} T$, and

$$\frac{L}{L_0} = \left(1 + \frac{B T^2 L_0}{\rho}\right)^{-1}$$

We now argue that, since the volume change on melting for these metals is very small, and the electrons are already nearly free electron-like in the solid state, e-e scattering should change very little as the solid melts. Thus, the above equation should give the observed $L/L_0$ values using...
the previously found $B$ values and $\rho$ measured for liquid K. It indeed does, as may be seen by comparing the dashed (model) curve with the actual data. As K melts, $\rho$ increases by some 50% and as a result $L/L_0$ increases; at higher temperatures, $L-L_0$ does not vary linearly with $T$, since $\rho$ increases faster than linearly with $T$.

It has often been stated that the transport properties of liquid metals are anomalous, in that for most of them $L$ is observed to be different from $L_0$, while no satisfactory mechanisms have been proposed. For the alkali metals in particular, it has been suggested that their low $L/L_0$ values are due to inelastic scattering of electrons by ionic density fluctuations, even though their low $\Theta$ values (where $\Theta$ is the Debye temperature) would suggest such scattering should be negligibly small.\textsuperscript{3} Our results indicate that $L/L_0$ is indeed below unity for liquid K at the temperatures considered here, and that this must not be attributed to such inelastic scattering, but to e-e scattering, which completely accounts for the difference between $L$ and $L_0$ both below and above the melting point. The transport properties of molten K are therefore not anomalous in the sense indicated above.

\begin{itemize}
\item 2) J.G. Cook, Proc. 16th Thermal Conductivity Conference (to be published).
\item 3) J.G. Cook, to be published.
\item 5) A.H. MacDonald and D.J.W. Geldart, to be published in J. Phys. F.
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